GOLDEN JUBILEE CELEBRATIONS

Souvenir 2000

Issued at the National Symposium on Eco - Friendly Mariculture Technology Packages - An Update, held at Mandapam Camp, 25 - 26 April 2000 to mark the Golden Jubilee Celebration of Staff Recreation Clubs

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Marine Pearl Culture

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Pearls are one of the gems which has a worldwide demand and has been exploited from the time immemorial. Pearl fishing was prominent all over the Middle East and Oriental countries during the early 4000 BC. The use of pearls as ornaments was well exhibited in the Egyptian civilisation as well as Sind Valley civilisation. Based upon the demand the Romans and Greeks had trade with Gulf of Mannar Coast (Tamilnadu) and Gulf of Kutch (Gujarat). The entire trade was totally depending on the natural pearl resources causing heavy of damage to the natural populations. To produce a pearl by the pearl oysters bit required at least 3 to 4 years unter natural conditions. The percentage of natural pearl formation was very small. The production of spherical pearls by the oysters in nature is rare. Kokichi Mikimoto, in 1893 produced few blister pearls in the Japanese pearl oyster ***Pinctada martensii (P.fucata)*** at the coastal village of Jinmiyonmura on Ago Bay. In 1907 Tokichi Nishikawa produced the first spherical cultured marine pearl in the oyster and the pearl culture industries started flourishing with a master touch of Mikimoto and several others. After the World war II pearl culture industry was established in Australia, Philippines, Burma (Mianmar), Thailand, Malaysia and Indonesia with Japanese collaboration. The 'paar' of Gulf of Mannar have yielded very valuable fisheries in past, since 1955 and then the beds have gone unproductive.

James Hornell as early as 1916 paved a way for the idea of pearl culture in India and Ceylon. Some experiments were conducted in Krusadai Island (Gulf of Mannar, Tamil Nadu) since 1938 and in Sikka (Gulf of Kutch, Gujarat) since 1958. The success in developing the technology of pearl production was achieved only in 1973 when the first batch of free spherical cultured pearls was produced at Central Marine Fisheries Research Institute, Tuticorin.

Records of pearl oyster resources and pearl fishery in India.

1835 - (Madras Coast Records) Feb - March 1834 - Jadhi Thalaivan - discovered 34 beds between Kootapuli - Kooduthalai (Cape Comarin) Clandestine fishing by fishermen depleted the stock.

1836 - Lt. Col. Monteitha , Superintending Engineer reported the occurrence of two and a half to three and a half year old oysters from Thollaiyar paar.

1839 - Mr. Franklin appointed for the inspection of pearl banks, 12 banks - Vaipar to Mookur, 21 banks - off Tuticorin, 24 banks - off Punnakayal, 14 banks - off Tiruchendur. Out of the above 21 banks of Tuticorin considered for good fishing grounds.

1841 - Mr. Franklin - reported that pearl oysters had disappeared from the beds, possibly due to natural causes.

1848 - Mr. Thomas, Collector of Tirunelveli - suggested the leasing of pearl banks to a wealthy merchant on 50-50 basis to check the poaching. Suggestion dropped. But 1849 report confirmed the fear and the entire oyster had disappeared.

1856 - Due to Suram - no oyster bed was found.

1858 - Results of inspection

recommended the possible fishery, during 1860 from 23 beds.

1860 - A pearl fishery from 23 beds off Tuticorin for 23 days. Yielded a gross revenue of Rs.250276.00

1860-1864 off Tiruchendur - 5 years old oysters found plenty reported by Captain Phipps after 21 days survey.

1866-67 'Paars' inspected only off Punnakayal with one year old stock.

1867 - 66 'Paars' were inspected during Jan-Mar. Young oyster settlement was seen in 15 of the 'Paars'.

1870 - Poaching was found near Nallathanni thivu - finding heaps of pearl oyster shells. People of Kilakarai and Valinokkam might have plundered the oyster beds - sparked big controversy.

1873 - Off Tuticorin banks - with very large quantities of young oysters were attached to the rocks and weeds.

1876 - Out of 18 banks - 5 'Paars' gave hope of fishery in 1878 - 1880.

1885 - GW Wicks completed inspection of 46 'Paars' are found off Tuticorin fit for conducting fishery.

1923 - Based on MT Lady Nicholson report fishery forecast for 1927 - 28.

1926 - 24 crores of oysters were estimated for fishing during 1926 with a 770 sq. miles area.

Declaration of rules under 6 of the Indian Fisheries Act of 1897 was made into effect for the prevention of poaching.

1927 - 29 Pearl fishery was in full swing Feb-Mar-33 days harvested, 14,096,839 number of oyster, Nov. - Dec. - 23 days, harvested, 1,608,931 oysters in Tholayiram paar.

Feb.-Apr.-27-days, harvested 10,337,050 oyster special feature of this fishery was the participation of 38 Arab divers. Dec 27- Jan. 28 of 7 days. and Mar-29-31 days - 9.6 million oysters harvested.

1937-Pearl oyster farming started near Kunthukal point at Krusadai Island

1940-74,519 oysters collected from Thanjavur and transported to Krusadai.

1941 - A total of 6782 pearl oysters were farmed and initiated pearl culture.

1956 - April to May - 3.058 million oysters from Tholayiram 'Paar' was collected fetching a revenue of Rs.1,46,000.00

1957 - Pearl fishery was continued for 51 days, 11,175 million oysters near Kudamuthu paar. Punnakayal, Tiruchendur paars 21 days fishing 8.3 million oyster.

1958 - 14 March - 26th May - 55 days - 21,476 million oysters from Kuruval paar.

1958 & 59 Dec. - Jan - 36 days 10.738 million from Kuruval paars.

1959-60 - 22 million oysters estimated in Tiruchendur Tholayiram and Kudamuthu paars.

1960-61 A total 16.175 million was fished.

1963-13 banks of Tholayiram 'paar' and Kuthdiar 'paars' estimated to be 20 million oysters reported by P.B.Salvadori. A total of 16.176 million oysters fished out for 30 days.

Pearl formation - Natural

The formation of pearls in the pearl oyster is due to the pearl secreting cells of the mantle migrating into the body of the oyster under the stimulus of a foreign body and by a series of cell division form a pearl-sac around the foreign body. The pearl-sac in turn secretes the nacre over the body , forming a 'natural pearl' in course of time.The natural pearl formation can occur with or without a nucleus. The formation of blister pearls also possible when a particle stick to the shell near the mantle tissue and due to irritation the nacre is secreted over the particle and forms a blister pearls.

Spherical pearl formation

The formation of spherical pearls in pearl oysters can be achieved by introducing a spherical nucleus into the gonad of the oyster along with a small bit of mantle tissue. The mantle tissue known as graft tissue introduced into the gonad start growing and forms a pearl sac, which secretes nacre over the nucleus and forms a pearl.

Pearl oyster resources in India

Distribution

Pearl oysters belong to the genus ***Pinctada.*** They enjoy a world wide distribution occurring in almost all the seas of the tropical and subtropical region. Six species of pearl oysters occur in the Indian waters viz. ***Pinctada fucata*** (Gould), ***P.margaritifera*** (Linnaeus), ***P.chemnitzii*** (Philippi), ***P.sugillata*** (Reeve), ***P.anomioides*** (Reeve) and ***P.atropurpurea*** (Dunker) of which ***P.fucata*** alone contributed to pearl fisheries in Gulf of Mannar and Gulf of Kutch.

The pearl oysters always found attached by byssus to some hard materials such as rocks, dead corals, outcrops or sand grits covered with marine organisms. In Gulf of Mannar the pearl oyster occurring area is known as pearl banks or 'paars'. There are 65 such pearl banks located between Kanyakumari and Rameswaram Island. These banks stretch between 12 to 20 km away from the coast at a depth of 15 to 25 meter. These paars were divided into three divisions. Northern or Kilakarai division extensively from Adam Bridge to Vaipar. The central division extends from Vaipar to Manapad and the southern or Kanyakumari division stretches from Manapad to Kanyakumari. Only central division is most productive because out of 40 fisheries (between 1663 and 1961), 39 fisheries had been taken place in this division.

In the Gulf of Kutch, the pearl oyster reefs are scattered along the southern part of the Gulf of Kutch. There are about 42 known pearl oyster reefs covering an area of 24,000 ha located between Sachana on the east and Ajod on the west. The beds are located in the inter-tidal region and are exposed at receding tides, known as 'khaddas'.

The black lip oyster ***(P.margaritifera)*** is confined mostly to Andaman waters. From Lakshadweep, settlement of spat of ***P.fucata*** and ***P.margaritifera*** are found on the ridges of rocks and corals.

Collection of Pearl oyster spat

Collection of pearl oysters from the natural beds is not always dependable due to their irregular production patterns. Three ways of collection of spats are there. They are (i) setting up of artificial spat collection at subsurface during oyster spawning seasons (ii) collection from natural beds and (iii) hatchery production. There are several practices for spat collection in different part of the world. In Japan shells of abalones, oysters and scallops and cedar springs are suspended from the rafts from just below the surface to about 3-m in depth for collecting the spat of pearl oysters. Similarly, the rope collectors, synthetic filamentous spindle, split bamboo collectors and coconut shell strings were used .

Pearl oyster hatchery technology

Central Marine Fisheries Research Institute has developed technology for hatchery production of pearl oyster *(P.fucata)* spat which is an important milestone in the progress of reseat and development in marine pearl culture in India.

Site selection

The primary requirement of an operational hatchery is the uninterrupted supply of good quality seawater, free from pollution. The seawater used for the hatchery should be free from suspended particles. The site for the water intake should be rocky coralline or sand mixed. It should be away from domestic or industrial sewages. The site should not be very close to river mouths, which may cause fresh water influx during flood resulting in low saline water. Other aspects to be considered are proximity to the natural resources and farm sites and logistics for transplantation.

Hatchery building

Hatchery building must have light control facility, and free air passage inside the hatchery. Water intake, outlet, drainage facility should be provided in order to prevent the water stagnation inside the hatchery. The flooring must be either concrete or granite or 'kadapa'stones, which provide a solid bottom, with gentle slope for easy washing and draining of spilled seawater.

Water source

Clean and pollution free seawater supply to the hatchery is very important. The water supply to the hatchery should pass through biological filters or high pressure sand filters initially and later to UV filter. PVC pipelines has to be used in order to avoid metal contamination of the water supply.

Aeration

The aeration can be provided by centrally fixed air compressors or air blowers. Air blowers are more suitable than the air compressors because the oil used in the air compressor may contaminate the quality of air. PVC pipe lines, tubes and regulators are to be used. Air stones must be provided to diffuse the air.

Brood stock maintenance

Brood stock maintenance is an important component for successful hatchery production of pearl oyster spat. The brood stock was brought to the laboratory from the open sea and maintained at 25-28°C. The oyster is fed with mixed micro algae. The brood stock is kept on a rectangular shallow FRP tanks (100 x 50 x 20 cm), filled with a small platform at a height of 5 cm to keep the brood stock oyster which makes easy for cleaning the faecal matters without disturbing the mother oysters.

Natural Spawning

The pearl oysters with matured gonads naturally spawns when there is slight change in the medium. In all the cases male will get induced first and release the spermatozoids, which triggers the female to release the eggs.

Induced Spawning

In order to operate the hatchery continuously, it is essential that induced spawning to produce larvae at required time is very important. There are different types of techniques applied to induce the oysters to spawn.

Chemical Induction

Hydrogen Peroxide at a dosage of 3 to 6 millimole induces spawning of 18.2% after 2 hours.

At pH 9.0 using the buffer 37.5% spawning can be achieved after 1-2 hours.

Thermal Induction

The thermal shock method found to be very safe and effective. When the brood stock

is kept at lower temperature 25-28.5°C and they are gradually exposed to 35°C the matured oysters respond due to the thermal shock and spawning process takes place.

Larval Development

Soon after the discharge of both male and female gametes the fertilisation takes place in the water media. The unfertilised eggs, after fertilisation attain spherical shape with an average size of 47.5µ. The first and second polar bodies appear. The first cleavage appears at 45 minutes after the fertilisation resulting in a micro mere and macromere and is called Trefoil stage. Then develops a small cilium, which makes the rotation movement of the embryo. Blastula is reached after 5 hours of the fertilisation; the formation of blastopore and blastocoel takes place within this stage. Gastrulation takes place by epiboly. The archenteron formed at this stage. The embryo exhibits phototropism during this stage. It takes 7 hours to reach the stage from the time of fertilisation. A tuft of cilia of preoral and postoral develops this making to the anterio - posterior region of embryo. It takes 10 hours to attain trochophore.

The veliger stage is reached by the formation of the straight hinge line, mantle rearrangement of preoral cilia into a velum and disappearance of the apical flagellum, preoral ciliary bands. The size of the larvae is 67.5 µ and it takes 20 h to reach the stage. The development of straight hinge larvae to umbo stage is gradual. Typical clam shaped umbo stage reached between 10-12 days. The mantle fold also develops in this stage. Eyespot is developed on the 15th day when the larvae reaches 190 x 180 µ in size. The eyespot is situated at the base of the foot primordium.

The foot is developed on the 18th day at the size of the 200 x 190 µ. This is a transititionals stage between swimming and crawling. Later the foot becomes functional and the velum disappears. 2-4 gill filaments are seen.

Plantigrade stage is reached on the 20th day and measures 220 x 200µ. Labial palps and additional gill filaments develop. Shell growth is visible.

Plantigrade transforms in to young spat. Hinge line, anterior and posterior auricles and the byssal notch assume specific shape. The left valve is more cancave than the right. The spat attaches to the substratum by means of byssal threads.

Feeding regime

First feeding starts at veliger stage and at this stage the larva require 5000 cells/day/ larvae. ***Isochrysis galbana*** forms the intial food. From 10-12 day the quantity is increased to double i.e. 10,000 cells/days/larvae and continued to 15th day. From 15th day, the feed is increased to 20,000 cells till the pediveliger. Spats are fed with mixed culture of ***Isochrysis galbana, Nannochloropsis*** and ***Chaetoceros*** spp with a domination of ***Chaetoceros*** in the culture.

Live food culture

Flagellates measuring less than 10µ forms the food of pearl oyster. The important phytoplanktons are ***Isochrysis glabana, Pavlova, Chromulina*** and ***Dicrateria*** spp. The most common method followed in the pearl oyster hatchery for stock culture of ***Isochrysis galbana*** is by using Walnes's or Conway medium.

Mass culture

From the stock culture, mass culture of micro algae produced at room temperature in 20-40 l tanks (Perspex). The composition of the medium used for the mass culture and mixed culture of algae is

Potassium nitrate	- 0.4 g
Potassium dihydrogen ortho phosphate	- 0.2 g
Sodium Silicate	- 0.2 g
EDTA sodium Salt	- 0.2 g
Filered seawater	- 30.0 l

Microalgal culture condition

The right amount of illumination is an important factor for the microalgal culture. Most of the flagellates require less light during the stationery phase. High light intensity may cause early declining of culture. The ambient levels of light is 1000 to 1500 lux for 4-5 days and for maintaining the stock further limited to 400-500 lux. Photoperiod of 12h day and 12 h dark is necessary for both stock and mass culture of microalgae at 23-25°C. Aeration is necessary for the mass culture of microalgae.

Nucleus implantation technique

Selection of oysters

Selection of mother oysters for the purpose of nucleus implantation is very important. The mother oysters must have ideal stage of gonad for the operation. Immature and maturing stage oysters are suitable. The oozing oysters are not suitable for implantation

Graft tissue preparation

The peripheral mantle portion of few healthy oysters are cut and removed. This mantle stripe is trimmed and 2 mm square pieces are cut. The graft bits are placed in filtred sea water and a small amount of Eosin stain is added.

Nucleus implantation

The oysters are fixed on a stand with a clip and the gonad region of the oyster is located and a small incision is made at the base of the food and taken into the gonad. A small twist is made while making the incision which will prevent the ejection of the nucleus. Then the operated oysters are sent to filtered running seawater tanks for a post operative care for three days and subsequently the oysters are ready for transplantion .

Farming methods

Raft culture

This method is found to be most suitable and appropriate one to farm the oysters in the sheltered Bays. Wooden poles lashed with coir ropes and floated with the help of buoys moored by 2 to 4 anchors tied by means of 15 mm nylon ropes. Wooden barrels, empty oil drums coated with M.S.Sheet barrels, Polythene barrels and FRP coated foam material are used as floating buoys for the purpose. A raft of 6 x 5 m is found to be more ideal for the pearl oyster culture and can accommodate 80-100 cages of 40 x 40 x 10 cm in size.

Collapsible or long line raft

A collapsible or long line raft comprised of 16 to 20 empty PVC barrels (200 litre capacity) arranged in a row or 4 rows connecting one another by a chain stretched and anchored to all the ends. Between the gaps, the pearl oyster cages are suspended. The collapsible cages are very convenient for erection and removal. The disadvantage of this type of raft is that the suspended cages get entangled during the rough weather and get damaged due to hitting with one another.

On bottom culture

This type of culture technique is possible only on the rocky sea bottom or articicial bottom either made up of old net materials spread on the bottom or by pavement of old pearl oyster cages over which old net materials are spread and tied at the corners by means of a erected poles. This is necessary to prevent the migration and falling of pearl oysters on the muddy bottom. In an area of 100 x 3 m, 300 oyster cages can be kept. This type of culture can be applied as a temporary means to accommodate the wild collected oysters before farming into off shore rafts.

Rack System

In this method, 3" dia GI pipe materials or 5" bottom casurina or eucalyptus poles erected at a depth of one metre into the soil in the sea with 2 to 3 m depth of water column at low tide. The gap between the poles is 3 m and they are

erected at a row of 3 or 4 into the sea. The poles are cross connected by means of wooden poles and tied by means of coir ropes. The gaps are inter connected by the same poles in order to accommodate 80 to 100 cages per compartments. This can be extended to a long distance more than 200 m from the shore to a depth of 3 to 5 m into the sea. This type of rack method culture system is very convenient for the operation and also to attend the farming work easily.

Environmental parameters

The growth of the oysters or spat totally depends on the primary producer's. The colour of the pearl is strongly affected by the water temperature, food availability, physiological conditions of the pearl oysters. But the bloom of ***Trichodesmium thiebautii*** may cause heavy damage to the pearl oyster.

The temperature plays an important role in the biological activity of pearl oyster, in Indian waters the ambient temperature is 25-30°C. The pearl oyster prefers high salinity but oyster raised in such water produces pearls with golden tint. The pearl oyster can tolerate with range of salinity from 25 to 40%. Beyond this levels the oysters may not survive for longer period. The pearl production depends on the depth of the water and usually 15-20 m the growth of the oyster found to be very good. But the minimum depth required for a good quality pearl is 5 m, which produces pink colour pearls.

In addition to the above factors, the bottom of the sea, water current, proximity to river flow and silt load, plays an important role to fix the quality of pearls.

Grades of pearls

Class A : Flawless, one flaw, small stain, pink silver or light cream; further categorised into A-1. Top pearls - perfectly round; pure, flawless and lustrous A-2. First class pearls with slightly large pits and protuberances.

Class B : Fairly large flaw, stains, cream colour, and irregularity in shapes.

Class C : Fresh pearls, wild shaped, badly coated, heavily pack - marked, and clayey lump half good and half bad.

Chemical composition of pearls (%) are as follows

Water	- 3.97
Organic matter	- 3.83
Calcite and aragonite	- 91.59
Loss	-0.61

Economics of pearl culture Raft Culture method
Raft size 6 x 6 m
Input cost (2 years)

	Rs.
1. Cost of poles , floats, anchors and anchor chain and ropes	13,000.00
2. Cages (100 Nos) for rearing 10,355 oyster	10,000.00
3. Cost of 10,355 oysters @ 1.40/seed	14,500.00
4. Cost of 9414 shell bead nucleus	9,500.00
5. Cost of chemicals & Glasswares & surgical instruments	5,000.00
6. Charges for pearl oyster surgery	3,000.00
	55,000.00

Production and revenue

Total pearl procured	1,849 Nos
1. Sale proceeds of 1296 pearls	Rs.73,133.00
2. Cost of 250 pearls distributed to fishermen in lieu of their	

labour	Rs.12,500.00

The remaining 303 pearls were of inferior quality and fetched low market price

The rate of return worked out 55.7%

(Source T.S.velayudhan, Technology Transfer Division Series 5).

Rack Culture

Total area	20 x 15 = 3000 sqm
	Rs.
Infrastructure facility farm	40,000.00
Cages (1000)	75,000.00
Rope and other accessories	30,000.00
Cost of oysters (1,00,000)	4,00,000.00
Nucleus	1,00,000.00
Cost of Labour (4 person - 12 months)	96,000.00
Watch and ward (3 persons)	54,000.00
Miscellaneous	15,000.00
Total expenditure	8,10,000.00

Revenue

Total No. of pearls harvested : 30,000

Class A 3000 nos and Class B 6000 Nos

On an average @ Rs.100/pearl	9,00,000.00
Class C 18000 Nos	3,60,000.00
Total	12,60,000.00

Source : ICAR Revolving fund project on pearl culture.